CHAPTER 20

MAINTENANCE OF DRAINAGE FACILITIES

CHAPTER 20 – TABLE OF CONTENTS

20.1 MAINTENANCE CONSIDERATIONS

20.1.1 Introduction

Drainage facilities perform the function of removal of water from streets, highway sections, parking areas and other drainage areas and the protection of the facilities from the effects of the water. These drainage facilities include drop inlets, storm drains, bridges, culverts, underdrains, ditches, slope protection, detention facilities and erosion control devices. For these facilities to function as designed and constructed, they must be properly maintained. Full consideration must therefore be given to this activity during their design. Designing drainage facilities that are as maintenance free as practical will often result in cost savings that, over the service life of the drainage feature, equal or exceed initial construction costs. Good drainage design practices recognize that all structures require periodic maintenance inspections and repairs. Reasonable access for maintenance personnel and equipment must be provided for this necessary function.

Communications between designers and maintenance personnel are essential. Design personnel are encouraged to contact maintenance personnel for their input on difficulties they identify in maintaining drainage facilities. Suggestions from maintenance personnel on how drainage facilities and future designs may be improved for efficient and effective maintenance should be invited.

Conditions that appear to require extensive repair or that incur frequent recurring maintenance should be referred to the ((District Hydraulics Engineer)) for review. Investigation may reveal that a complete redesign is more cost effective than repetitive repair. Reports by the maintenance forces of both effective and non-effective hydraulic installations aid designers in future work. For additional information, see Reference *(5)*.

20.1.2 Maintenance Program

Highway maintenance is the preservation and upkeep of the roadway, structures and appurtenant facilities as nearly as possible in the condition in which they have been constructed.

Maintenance functions relative to highway drainage vary from establishing and caring for vegetative cover on slopes for erosion control purposes to extensive emergency repairs resulting from major storm damage.

Minor improvements to drainage facilities and betterment work, although often performed by maintenance forces, are not generally classified as maintenance functions.

Routine maintenance of highway drainage structures and facilities include:

- performing semi-annual inspection to ensure that the facilities are functional and operating as designed;
- performing miscellaneous preventative maintenance to forestall deterioration of the facilities;
- cleaning accumulation of debris, sediment and vegetation from the facilities; and
- repairing or replacing damaged elements of the facilities according to severity.

Storm damage to major channels and structures can be both expensive to repair and hazardous to traffic. In addition to periodic maintenance, the maintenance program should include inspections and repairs following major storms and floods.

Typical drainage structures and facilities that receive routine maintenance include:

- bridges over waterways,
- pumping plants,
- shore protection devices,
- bank and erosion control measures,
- culverts and appurtenances,
- ditches and channels,
- storm drains and appurtenances,
- stormwater storage basins, and
- underdrains.

20.1.3 Records

Appropriate records should be kept of significant repairs made to drainage facilities. A record should also be made of the extent, frequency and duration of roadway overtopping, exceptional highwater, unusual flow conditions, and any other peculiar conditions (e.g., scour of the streambed, bank altering the channel during high-water periods). A record of the highest high-water mark for major streams should be indicated by painting a mark and date on the abutment, pier or column.

20.1.4 Problems

Roadway maintenance operations that require lane closures on heavily traveled highways, particularly metropolitan freeways, are costly and may compromise the safety of maintenance workers and the traveling public. Good drainage designs eliminate or reduce the need for traffic control measures for cleaning drainage systems and facilities. Drainage inlet types and pipe drains that are designed to be as self cleaning as possible should be specified where practical.

The routine cleaning and minor repairs of highway drainage features often require that labor-intensive hand methods be used. Adequate access for maintenance personnel and equipment to get to the site and do work on drainage facilities should be provided in the plans. In addition, most costly maintenance work might easily be avoided, or more efficiently accomplished, if designers give more attention and thought to the shape and location of drainage features. For example, a V-shaped roadside ditch that is contiguous to the shoulder can be efficiently reshaped and cleaned with a motor grader. Small trapezoidal and other shaped roadside ditches may require hand cleaning or special equipment.

Locating drainage inlets where trash and sand naturally tend to accumulate causes clogging of grate-type inlets and pipe drains. Where practical, drainage inlets should be located where sweeping operations will not deposit additional debris in drainage facilities. Inlet and junction boxes and other minor drainage structures that are subject to periodic cleaning must be made large enough that maintenance workers can enter them and work with either hand tools or heavy-duty vacuum equipment.

Several types of bank protection and erosion control materials are classified as flexible or self-adjusting and, as a rule, are less of a problem to repair and maintain than are the rigid linings. Materials requiring less maintenance attention should be specified.

20.2 INSPECTION

Maintenance of drainage facilities is very important both during the development and construction of a project and afterwards. In some areas, maintenance of natural drainage systems presents minimal problems while, in other areas, major resources will need to be allocated for maintenance-related tasks.

Drainage inspections should be made semi-annually and during and after each major storm to confirm that satisfactory conditions exist or to evaluate the need for cleanup and repair. Inspection schedules should include mandatory inspection of known trouble areas and inspection of other areas as appropriate.

The best times to look at drainage facilities are often during and immediately after a storm. It is easy then to see where water ponds and where drainage facilities are overflowing and to observe the resultant damage. The inspector should be alert to any pavement cracks or settlements that appear after a severe storm, even if these defects are small, because they may be evidence of an erosion caused by a break in the pipes. Areas that generate large amounts of sediment and debris should be identified. Also, locations within the drainage system where debris and sediment accumulate should be identified and included in any preventive maintenance schedule.

A record of the inspection should be kept with any deficiencies recorded.

20.3 DETENTION FACILITIES

20.3.1 Introduction

Detention facilities are often used in urban drainage systems to temporarily store or detain excess stormwater runoff and then release it at a regulated rate to downstream areas. Using this approach, runoff is stored in constructed or natural basins from which it is released continually until the water elevation in the facility reaches its design dry-weather stage. To function properly, the storage volume must be maintained at its design level, and outlet facilities must be kept open and free from obstructions or clogging.

20.3.2 Maintenance Problems

See the Storage Facilities Chapter for specific maintenance problems associated with detention facilities.

20.3.3 Maintenance Program

A good maintenance program should include preventive maintenance and corrective maintenance. The maintenance program should include:

1. periodic inspection, adjustment, replacement;

2. preventive maintenance — doing maintenance to prevent problems from occurring (e.g., removal of debris at inlets); and

3. corrective maintenance — making changes to the system so that the system functions as intended at the lowest annualized cost (e.g., resetting an inlet to reduce ponding).

The major prerequisite for a preventive and corrective type of program is an assured source of funds. The other component of a maintenance program, emergency repairs, is characterized by crisis-type responses to problems that go unrecognized, or are unattended, over a lengthy period of time. Often, such problems are treated as emergencies and, in some instances, little time is available for study, design or competitive bidding.

20.3.3.1 Inspection Intervals

Inspection of major detention facilities should be made as frequently as experience shows necessary, more often in wet seasons. Where debris is a problem, inspections must be spaced according to debris generation. In any event, it is important to conduct inspections and cleanup work following major individual runoff events. It is sometimes necessary to make inspections during rainstorms when intense rainfall occurs.

Besides removing debris blockages during inspections, mechanical equipment (e.g., generators, float valves, pumps, discharge controls, other electrical and mechanical equipment) should be checked and adjusted as necessary.

20.3.3.2 Maintenance Tasks

Maintenance tasks can be grouped into three general categories:

1. aesthetic maintenance,
2. nuisance maintenance, and
3. operation maintenance.

Of these, the most important, considering health and safety, is operation maintenance.

20.3.3.3 Maintenance Operation

This category can be characterized as that level of maintenance required to ensure against failure of major structural components and/or flow controls, and to ensure that the detention facility continues to function as designed. Neglecting this level of maintenance could cause failure and subsequent property damage and possible loss of life. In addition, neglect can cause a facility to cease functioning as it was originally designed to do. A program of scheduled, periodic inspections of the facility is essential to recognize potential structural maintenance needs. The following is a partial list of items that should be checked periodically and corrective action taken as required:

- settling of dam;

- woody growth on the dam (roots can create channels for dam leakage and eventual failure);

- signs of piping (leakage);

- signs of seepage or wet spots on the downstream face of a dam (may require toe drains or chimney drains to solve problems);
- riprap failures;
- deterioration of principal and emergency spillways;
- deterioration or damage to various stage/outlet controls;
- effectiveness of debris racks;
- outlet channel conditions;
- safety features (access controls to hazardous areas);
- mechanical and electrical equipment (pumps, generators, automatic controls, etc.);
- access for maintenance equipment;
- availability of manufacturer's mechanical and electrical information manuals; and
- availability of design information (e.g., rating curves and tables for spillway flow, bypass flow, total flow, storage and pump-out calculations).

In addition, the following actions should be taken on each dam as required:

- Replace soil removed by rodent burrows.
- Inspect drainage systems and relief wells annually for proper functioning and cleanout or replace as necessary.
- Maintain riprap or other wave-protective measures and replace as needed.
- Remove and/or stabilize slide material as soon as practical. It may be necessary to construct a berm or flatten the slope.
- Replace eroded material and establish vegetation in eroded areas in emergency spillways, swales and other areas.
- Repair any unusual seepages, boils or settlements in fill areas or sinkholes in pool areas.

Also, observations should be made of any changes in topography, downstream drainage systems or land uses that may have a bearing on the operational effectiveness and safety of detention facilities.

For more information on stormwater facility maintenance, see Reference *(3)*.

20.3.3.4 Volume Maintenance

One of the most important variables in the design of a detention facility is the volume available for storage of runoff. If a detention facility is allowed to accumulate sediment and debris that will decrease the storage volume, the ability of the facility to function as designed can be greatly reduced. Thus, it is essential to maintain the design volume. To facilitate the inspection of the facilities for volume control, it is recommended that some marker be installed in the detention facility to indicate the maximum level for silt buildup before the facility must be dredged or cleaned. This marker could be a small pipe with a stripe or suitable indicator at the cleanout level. A suitable indicator could also be placed on the outlet device or in some location that can be easily identified during the inspection process.

20.4 STORM DRAINS

20.4.1 Maintenance Problems

Storm drains convey the water collected from catch basins, drop inlets and detention facilities to the natural water courses.

The maintenance involved in storm drain systems is the removal of any sand, silt or debris and the maintenance of a soil-tight seal at each pipe joint. There are occasions where abrasive material is present in the water (or some chemical that has a deleterious effect on the pipe) that causes the pipe material to be worn away. This necessitates relining the pipe to preserve its integrity. It is recommended that the entire storm system be inspected every 10 years. Components that are more prone to sediment and debris deposition, such as catch basins, bubble chambers and inverted siphons, should be inspected yearly.

20.4.2 Cleaning

Water flushing and heavy-duty vacuum equipment can remove most partial clogs. More stubborn blockages can be cleaned by inserting a rodding machine (heavy-duty sewer snake) in one access hole and running it through to the next access hole.

20.4.3 Stormwater Inlets

Stormwater inlet structures are designed to intercept water in gutters and drainage courses. They also act as settling basins to collect heavy solids, and they prevent debris from entering culvert systems. Mobile heavy-duty industrial vacuum equipment is used to clean sediments from catch basins.

Grates on catch basins are used to prevent large objects and debris from entering the system. Frequent inspections are required because debris catches on the grate and prevents water from entering the catch basin. Many times, the time of rainfall is too short to allow for self-cleaning of the system, and debris tends to buildup over time.

Large catch basins constructed without a grate may collect large quantities of rock. This rock may be removed by lowering a clam or backhoe bucket into the catch basin. All muck should be removed.

20.5 CULVERTS

20.5.1 Culvert Maintenance

Culverts must be kept free of obstructions. Sand or sediment deposits should be removed as soon as possible. Inlet and outlet channels should be kept in alignment and vegetation controlled to minimize any significant restriction of flow. Reinforced concrete box culverts require little maintenance, but they should be inspected every 2 to 4 years for cracks, bottom erosion and undermining at outlets. Undermining is generally the result of high outlet velocities. Correction of undermining usually requires adding an energy dissipator.

For more details, see Reference *(4)*.

20.5.2 Cleaning

Culverts may become clogged if the flow-line grade is too flat to maintain self-cleaning velocities. A permanent correction is to reposition the pipe on a steeper grade, but this is not always possible and is often very expensive. The alternative is to clean the pipe frequently.

Small culverts may be cleaned by flushing away debris with water pressure. An alternative method of cleaning small culverts is to use mobile heavy-duty industrial vacuum equipment.

Some large culverts over 36-in diameter must be cleaned by hand. A small sled or wagon is useful for transporting material from inside the barrel to the culvert ends. In some cases, a small rubber-tired tractor, equipped with a push blade, may be used to remove sand and silt deposits from the larger concrete culverts.

20.5.3 Repairing

If the invert of a metal or concrete culvert becomes worn or eroded, it can be repaired by relining with concrete grout, gunite or asphalt cement. If the hydraulic capacity of the culvert is not critical, a liner pipe can be placed inside, and the annular space between the pipes can be filled with grout.

High-velocity flows, containing large quantities of stone and rock, scour the culvert bottom. Scour may be reduced by securing steel plates longitudinally along the bottom. Scour around footings, cutoff walls and headwalls is repaired by replacing the eroded material in kind and by protection against future scour with riprap or sacked concrete. In an emergency, a bituminous mix may be used.

When concrete pipe culverts settle, joints pull apart. Joints are repaired by tamping or rodding grout into the cracks.

To prevent erosion, energy dissipators are sometimes placed at outlets of culverts and drains. It is important that these be inspected periodically, particularly after major flows, to ensure that they are in place and functional.

Additional information on repairing culverts can be found in Reference *(1)*.

20.6 DITCHES

20.6.1 Ditch Maintenance

Ditches convey water away from roadways and other areas. Ditches may be unlined or lined with portland cement concrete, gunite, masonry, concrete or aggregate lining, quarry rock, bituminous concrete or vegetative material. Ditches should be kept free of silt, debris, large amounts of vegetation or any other material that restricts the flow of water.

The flow lines of unlined roadside ditches should be maintained by motorized equipment supplemented with hand work at least every 5 years.

Large roadside ditches are sometimes located at an elevation well below the roadway and not accessible to a motor grader. These may be reached with a truck-mounted hydraulic excavator operated from the shoulder.

Interceptor ditches on slopes, and along excavation or embankment benches, and outlet ditches from culverts may require hand cleaning by using shovels and wheelbarrows. Ditches lined with bituminous material oxidize or weather rapidly and should be sprayed with asphalt emulsion.

20.6.2 Repairing

Joint separation is a common problem associated with rigid lining materials. Once water gets under the concrete or asphalt, the underlying soil is removed and deterioration may be rapid, so frequent inspection is vital and fast repair a necessity if the investment is to be protected. If not immediately repaired, erosion occurs under the lining, causing it to crack and sometimes drop.

20.6.3 Erosion and Vegetation

Ditch erosion is the loss of soil caused by the rapid flow of water. It is controlled by paving the ditch with asphalt or concrete; by establishing erosion-resistant vegetation; or by constructing wash checks. Because erosion is serious, any case of erosion should be reported to the Region Maintenance Engineer.

Because erosion is one of the major problems with ditches, the growth of vegetation is encouraged. The vegetation may be maintained by adjoining property owners but, more often, must be maintained by the local agency. One of the major problems when vegetation is used to control erosion in ditches is the control of weeds. Proper timing of mowing operations will help control weeds.

20.7 SLOPE DRAINS

Slope drains are paved or metal troughs or pipes used to carry water from a collector drain, gutter or ditch into a roadside channel or natural water course. They should have firm contact with the supporting surface. If connected to a pavement or dike, a tight seal shall be maintained. Cracks should be sealed with a hot rubber asphalt compound.

The outlet end of slope drains should be inspected regularly for erosion. Eroded areas should be repaired. Sometimes the repair may include extending the drain.

Metal pipes used for slope drains on high embankments or benched excavations should be rigidly attached to the surface with pipe anchors. Anchors are designed to prevent the pipe from separating at joints but, in spite of this, separation occasionally will occur. Repairs consist of removing, reinstalling and anchoring all pipe below the separation.

20.8 WASH CHECKS, ENERGY DISSIPATORS AND BANK PROTECTION

20.8.1 Wash Checks

Wash checks are used to collect water, redirect its flow, provide settlement basins for siltation control and control the rate of flow. They are constructed of reinforced concrete or grouted stone.

Wash checks should be inspected for undermining especially after a period of heavy runoff. Undermining should be repaired.

20.8.2 Energy Dissipators

Energy dissipators are used at the outlets to culverts flowing with inlet control and therefore supercritical velocities. Energy dissipators reduce outlet velocities to enable the downstream channels to better sustain their integrity. Energy dissipators come in many forms. They should discharge into an area stabilized by vegetation at a minimum. They should be inspected for undermining after periods of heavy runoff, and any undermining should be repaired.

20.8.3 Grouted Riprap Protection

This type of protection is susceptible to undermining failure. Undermining leaves a void under the grouted riprap that ruptures and may cause the riprap to collapse into the void. Repair consists of filling the voids and collapsed surfaces with rock and grouting.

20.8.4 Concrete Slope Paving

Concrete slope paving is a rigid type of slope protection composed of concrete reinforced with wire mesh. It is subject to damage by undermining, hydrostatic pressure and material being washed through cracks. If degrading of a stream or scour exposes the toe, the toe should be protected with grouted rock. Weep holes should be placed in the slope paving if there is a possibility of hydrostatic pressure behind the paving. Weep holes may be placed by drilling approximately 2-in diameter holes in the slope paving. If cracks develop that permit the backing material to be washed out, they should be sealed. When the toe wall of concrete slope paving becomes exposed, it should be repaired.

20.8.5 Gunite Slope Paving

Failures and their causes and methods of repair are outlined under the preceding paragraph.

20.8.6 Retards and Permeable Jetties

Maintenance of such structures is confined primarily to the replacement of stone fill.

20.8.7 Gabions

Maintenance problems associated with gabions are minor in nature and consist mainly of patching wire mesh and the addition of wire and clips.

20.9 UNDERDRAINS

Underdrains should be checked in the early part of the wet season to ensure that they have not become clogged with sand or roots and that outlets are free to drain. Presence of silt or dirty water coming out of an underdrain indicates a possible break in the pipe. This should be reported to the responsible agency at once so that an investigation and remedial measures can be initiated.

Suction pumps, high-pressure pumps or powered rotary sewer cleaners are required to clean out long sections of clogged pipe. When the pipe becomes clogged, the filter material has failed or its effectiveness has been reduced to a level that makes it necessary to consider replacement.

Perforated pipes (smaller openings) sometime become clogged with algae and fine soils. They should be cleaned with high pressure water jet.

20.10 BRIDGES

20.10.1 Introduction

Bridges must be kept free of obstructions. Debris and vegetative growth under a bridge may contribute to scour, create a potential fire hazard and reduce freeboard for ice and debris during high-water flows, resulting in a serious threat to the bridge. A reduced effective flow area under the bridge may also result in excessive bridge backwater damage, more frequent roadway overtopping and a hazard to the traveling public.

Maintaining a channel profile record and revising it as significant changes occur provides an invaluable record of the tendency toward scour, channel shifting and degradation or aggradation. A study of these characteristics can help predict when protection of pier and abutment footings may be required. Being able to anticipate problems and taking adequate protective steps will avoid or minimize the possibility of future serious difficulties.

Maintenance inspection must be commensurate with the risk involved. Where probing and or diving are necessary, the inspection should be scheduled at the season of lowest water elevation. High-water, high-ice and debris marks with the date of occurrence should be recorded for future reference.

Additional details on bridge inspections and maintenance can be found in Reference *(2)*.

20.10.2 Maintenance Problems

Following are some of the maintenance problems that can be encountered:

- clogging of bridge deck drains and scuppers, which may create a hazard to traffic and contribute to deck deterioration;

- discharges of bridge deck drains that are detrimental to other members of the bridge and those spilling onto a traveled way below; in addition, discharges that may cause fill and bank erosion;

- clogging of air vents in the superstructure or deck of bridges subject to overtopping that may increase buoyancy forces and the possibility of bridge washouts;
- accumulation of debris in the open space between the handrails of bridges subject to overtopping that may induce additional lateral forces on the bridges and increase the risk of washouts;
- channel aggradation or degradation;
- scour at piers and abutments caused by accumulation of debris and or excessive velocities;
- damage to bridge approach embankment caused by channel encroachment;
- loss of riprap due to erosion, scour and wave action;
- damage to bridge elements due to debris, ice jams and excessive velocities; and
- missing navigational signs and lights over navigable channels.

20.10.3 Maintenance Measures

Maintenance measures include the following:

- repair of damaged bridge elements;
- a schedule for removal of debris after major floods;
- removal of sand and gravel bars in the channel that may direct stream flow in such a manner as to cause harmful scour at piers and abutments;
- cleaning bridge deck drains and keeping their outlets away from traffic underneath; also providing riprap or other means of protection at outlets to avoid fill and bank erosion;
- removal of debris caught between bridge handrails and opening vent holes designed to reduce buoyancy;
- making a channel change when necessary to redirect the flow away from bridge approaches and in-line with the bridge skew;
- dredging of channels that are subjected to a high degree of aggradation to maintain waterway adequacy;
- constructing cutoff walls to reduce or stop progressive channel degradation;
- replacing lost dirt in scour holes and constructing riprap mats or other means of protection for undermined piers and abutments;
- replacing missing riprap on embankment slopes, channel banks and spur dikes;
- replacing missing or damaged navigational signs and lights;

- constructing additional openings to accommodate increased urbanization in the drainage area upstream from the bridge; and
- modifying or increasing existing protective measures when needed.

20.11 REFERENCES

(1) AASHTO, *Highway Drainage Guidelines*, Chapter 14, "Culvert Inspection, Material Selection and Rehabilitation, " Task Force on Hydrology and Hydraulics, 2003.

(2) AASHTO, *Manual For Condition Evaluation of Bridges,* 2000.

(3) American Public Works Association, *Urban Stormwater Management*, Special Report No. 49, American Public Works Association, 1313 East Sixtieth Street, Chicago, IL, 1981.

(4) Federal Highway Administration, *Culvert Inspection Manual,* FHWA-IP-86-2, July 1986.

(5) Federal Highway Administration, *Integration of Maintenance Needs into Preconstruction Procedures,* FHWA-TS-78-216, 1978.